SCIENCE FOR GLASS PRODUCTION

UDC 666.247:666.1.022:666.12.001/.003

USE OF LOCAL RAW MATERIALS IN THE PRODUCTION OF LIGHT-RESISTING FLOAT GLASS

V. I. Kondrashov[1] and N. N. Shcherbakova[1]

Translated from Steklo i Keramika, No. 7, pp. 3 – 4, July, 2000.

The experience of the Saratov Institute of Glass in replacing Tashlinskoe sand by local sand with a variable chemical composition in the production of light- and heat-protective float glass is described. Practical recommendations are presented.

The development of commercial technologies for processing plate glass and the widening of the range of its application in the building industry, the production of furniture, and the automobile industry have changed the requirements on the quality and appearance of the glass.

The glazing of modern buildings performs several new functions, namely, formation of a microclimate, improvement of the light regime of the apartments (illumination), and protection from the heat arriving from the outside. These problems can be solved simultaneously by using polished light- and heat-resistant glass.

Solar radiation reaches the tarth in the range of wavelengths of 0.3 – 2.5 μm. Visible radiation corresponds to a wavelength of 0.38 – 0.76 μm. The thermal effect of visible rays is considerable and amounts to 44 – 46% of the total solar radiation. Conventional silicate glass transmits visible rays well, namely, up to 90% of the incident flux. Infrared rays in the range of 0.760 – 2.500 μm are invisible and bear 50 – 52% of the thermal radiation, and colorless glass transmits about 80% of the incident flux. The visible transmission and the transmission in the infrared range determine the light-protective properties of the glass.

In order to reduce the transmission of light the glass can be colored in the liquid state by iron(II) and iron(III) oxides; glass containing iron(II) oxide has the highest capacity for absorbing IR radiation.

Iron is introduced into the glass predominantly by two methods, namely, with crocus and iron scale or in the form of iron powder (metallic iron). The proportion of bi- and trivalent iron in the glass is stabilized by using reducing agents, namely, charcoal, coke, graphite, metals (tin, aluminum, magnesium), silicon nitride, etc..

If the blend is enriched with cobalt, nickel, and selenium, the glass can provide the requisite absorption not only in the infrared region but in the visible range of the spectrum too; such glasses have a blue, gray, or bronze shade.

The raw materials for the production of light- and heat-resistant and sheet glass should have a specific purity.

The Saratov Institute of Glass has implemented the production of light- and heat-resistant glass colored by sands of the Saratov Region that bear up to 0.6% iron as recalculated for Fe_2O_3.

The sands are represented by detritus rocks with a particle size ranging from coarse (1.00 – 0.50 mm) and medium (0.50 – 0.25 mm) to fine (0.25 – 0.10 mm). The sands of the Aleksandrovskoe deposit are fine-grain.

A screening analysis of the Aleksandrovskoe sands has shown the presence of a large proportion of fine grains, the proportion of grains less than 0.25 mm in size exceeds 65% (69 – 73%), whereas in the standard Tashlinskoe sand it is 50 – 53%.

The sands can be homogeneous and composed of one mineral or mixed, heterogeneous, and composed of various minerals.

The latter bear substantial amounts of feldspars and amphiboles (chain silicates with a hardness, optical properties, and density close to those of pyroxenes) in addition to quartz. The other components are micas (layered silicates with the layers bonded by Fe^{2+}, Fe^{3+}, Mg^{2+}, Al^{3+}), hydrated silicates of magnesium and iron, and detriments of various rocks, limes, and shales.

[1] Saratov Institute of Glass, Saratov, Russia.

0361-7610/00/0708-0227$25.00

The sands always bear a certain amount of clay particles. Aleksandrovskoe sand screened through screen No. 64 yields 3.0 – 3.5% clay particles. They give color to the sand together with limonites, i.e., amorphous or cryptocrystalline formations colored from yellow-brown to black.

The impurities in the composition of the quartz sand of the Aleksandrovskoe deposit can be classified into three groups:

– clay minerals with a fine crystalline structure, secondary minerals of the weathering zone;

– granular mineral impurities present in the quartz sand in a free state; the minerals of this group contain oxides of a number of metals, silicates, carbonates, etc. (pyroxenes, chlorite, glauconite);

– autogenous formations on the surface of quartz particles, i.e., films; the main components of the films are silicic acid, alumina, and iron hydroxides.

Iron oxides constitute a considerable part of the substance of the films. They are present predominantly in the composition of the minerals, namely, hematite Fe_2O_3 with FeO and TiO_2 impurities and goethite FeO(OH) known as limonite and colored from yellow-brown to black.

The open pit of the Aleksandrovskoe deposit has three levels, the lower of which is used for building purposes, and the middle and upper ones serve for the production of light- and heat-resistant glass.

The chemical composition of the sand differs both over the vertical levels and along the horizons.

A chemical analysis of the arriving sand has shown that the content of SiO_2 varies by up to 1%. The content of Al_2O_3 in the sand treated in the weighing line fluctuates by 0.14 – 0.44% at a total content of Al_2O_3 on the order of 2%. The total content of iron varies within 0.62 – 0.39% at a difference of up to 0.16% in subsequent batches. Titanium oxides are contained in an amount of up to 0.2%; in Tashlinskoe sand their maximum content is 0.02%.

It is known that the final glass bears no cord when the maximum fluctuation in the content of SiO_2 and Al_2O_3 in the raw material used is 0.40% and 0.25%, respectively.

Thus, the use of a raw material with the variable chemical composition just described can lead to chemical inhomogeneity of the blend and the melt [1].

The optical properties and the quality of the surface of sheet glass can worsen in the presence of layers enriched in SiO_2; on the surface they have a lower TCLE, and they compress the internal layers. If the external layer has a high TCLE, the tensile stresses in the surface layer can form notches. The TCLE of the glass diminishes when Al_2O_3 is introduced with the Aleksandrovskoe sand at the expense of SiO_2. The change in the TCLE is determined by the decrease in the strength of the chemical bonds due to the weakening of the force of the field of the cations and their ionic potentials. Introduction of Al_2O_3 at the expense of SiO_2 can reduce the microhardness because of the difference in the strength of the Me – O single bonds.

It is known that the liquid glass arriving for shaping consists of layers that differ in the time of residence in the furnace. The top layer of the glass is "younger," i.e., bears structural information of the recently loaded blend. In this case, the ribbon possesses layers that differ from the main glass composition in the refractive index, the anisotropy, and other properties [2]. They create optical distortions that are visible in transmitted light upon use of the "Zebra" method. This worsens the quality of the glass.

The use of sands with a high and unstable content of iron oxides creates some difficulties, namely, the liquid glass can acquire an undesirable color that has to be corrected. Constancy of the coloring of the liquid glass in the furnace is necessary for preservation of the diathermancy of the melt at the same level and, consequently, for stabilization of the temperature fields in the melt itself and of the convection flows in the liquid glass.

The maximum radiation of the torch and the arch in a tank furnace at conventional melting temperatures (1500 – 1600°C) is close to 1500 nm [3], and the Fe^{2+} ion in sodium-lime glasses has an absorption maximum at 1050 nm. In this connection, the total content and the proportion of different forms of iron in the melt affect directly the radiant heat transfer and the thermal diffusivity over the depth of the molten pool.

With an unstable content of iron oxides in the sand and, consequently, a variable light transmission of the melt the upper layer of the melt can be superheated and the bottom layers heated. In this case we cannot exclude the danger of crystallization of the liquid glass [4].

Iron oxides present in the sand can dissociate in the molten glass at a temperature of 1000°C with the emission of oxygen, i.e.,

$$6Fe_2O_3 \rightarrow 4Fe_3O_4 + O_2;$$

$$2Fe_2O_3 \rightarrow 4FeO + O_2,$$

which can cause foaming and increase the area of the surface of the melting foam.

Thus, we can formulate the main problems arising in passing to the use of the local raw material, which should be solved in commercial production of light- and heat-resistant glass in a float line with allowance for the experience of the Saratov Institute of Glass, namely:

– changes in the system of laboratory control of the chemical composition of the raw materials;

– a change in the established proportion of the raw materials in the blend because of the considerable excess of iron, aluminum, and calcium oxides relative to the Tashlinskoe sand.

This means that the following measures have to be taken:

– a substantial correction of the blend composition with allowance for the changes in the content of the main substance, the aluminum and iron oxides in the arriving sand, and the individual components of the blend;

– correction of the blending regimes, namely, the order and duration of entry of the materials into the mixer, their moistening, etc.;

– correction of the regimes of glass melting, choice of the optimum gas flow rate and distribution of the gas among the burners, correction of the pressure in the furnace, etc.;

– development of a method for computing and introducing coloring additives in order to maintain the requisite color and light transmission in the glass.

The scarceness of natural materials that meet the requirements of production of float glass and the difficulties arising in the replacement of the blend components can be compensated with the help of technical solutions developed by the Saratov Institute of Glass for lines for manufacturing light- and heat-resistant glass with allowance for the production cost and the purpose of the product.

REFERENCES

1. Z. A. Mikhailova-Bogdanskaya and V. V. Pollyak, "Effect of the chemical inhomogeneity on the quality of commercial glass," *Steklo Keram.*, No. 11, 15 – 17 (1972).
2. V. A. Zheleztsov, D. L. Orlov, N. A. Pankova, et al., "Effect of the conditions of preparation of liquid glass on the quality of sheet glass with respect to optical distortions," *Steklo Keram.*, No. 4, 6 – 8 (1973).
3. G. Jebsen-Marvedel' and R. Bruckner, *Types of Rejection in Glass Production* [Russian translation], Stroiizdat, Moscow (1986).
4. I. N. Gorina, V. I. Kondrashov, and B. E. Romanov, "Heat-absorbing sheet glass," in: *VNIIÉSM, Issue 1* (1986).